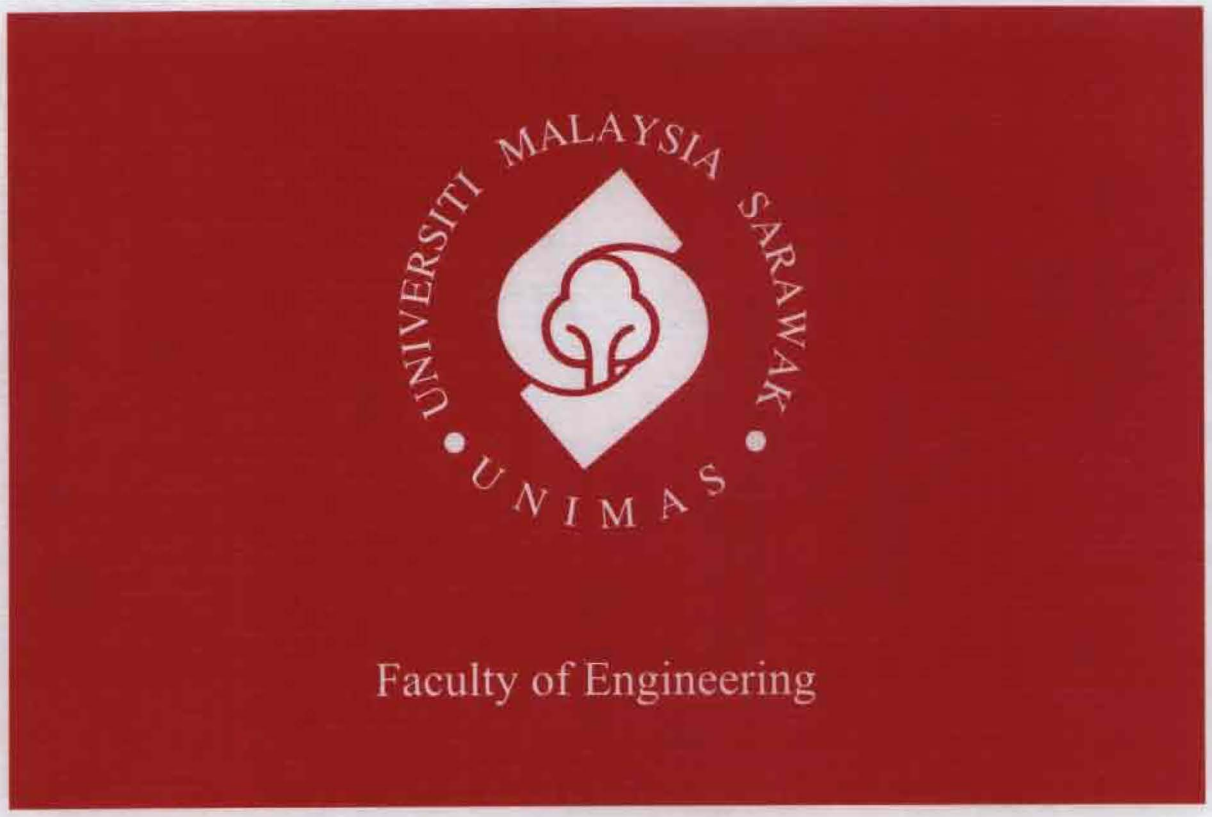

ELECTROMAGNETIC BAND GAP (EBG) STRUCTURE

Nurliyana Binti Hussaini

Bachelor of Engineering with Honours
(Electronics and Telecommunication Engineering)
2012

UNIVERSITI MALAYSIA SARAWAK

Grade: A

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Final Year Project Report	√
Masters	
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ELECTROMAGNETIC BAND GAP (EBG) STRUCTURE

NURLIYANA BINTI HUSSAINI

This project is submitted in full fulfilment of
The requirements for the degree of Bachelor of Engineering with Honors
(Electronics and Telecommunication Engineering)

This thesis is dedicated to my beloved family and supportive friends

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In the name of Allah, the Most Beneficent and Most Merciful, Who has created the mankind with knowledge, wisdom and power.

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Last, but most definitely not least, I am grateful to my family for their limitless patience and support. They encourage me to produce a good project. Their advice makes me strong to face all the problems in this project.

ABSTRAK

Projek ini telah dibangunkan untuk mengaplikasikan konsep struktur Elektromagnetik Selar Jalur (EBG) di dalam rekaan antenna. Aplikasi struktur EBG dalam rekaan antenna adalah penting untuk mengurangkan 'mutual coupling' yang mana merupakan masalah kritikal dalam rekaan antena terutamanya antena 'array'. Projek ini mempunyai dua eksperiment iaitu struktur EBG seperti cendawan bulat (cmEBG) dan antenna 'microstrip array' dengan struktur EBG. Bagi struktur cmEBG, kaedah yang telah digunakan ialah 'suspended transmission line' manakala bagi antenna 'microstrip array' dengan struktur EBG adalah kaedah 'inset feed microstrip transmission line'. Keputusan untuk kehilangan kembali, corak pemancaraan dan gandaan diperolehi dengan menggunakan perisian CAD CST Microwave Studio. Dalam eksperimen struktur cmEBG, struktur EBG telah direka untuk bekerja dengan cekap pada 2.4GHz. Oleh itu, kajian parametrik telah dijalankan ke atas struktur cmEBG untuk mengkaji karakter cmEBG.Parameter yang terlibat adalah jejari cmEBG (rebg), jejari via cmEBG (vebg), ketebalan substrat (st) atau panjang via (vl) dan jurang mendatar dan menegak. Rekaan struktur cmEBG yang optimum telah diaplikasikan ke dalam rekaan antenna 'microstrip array' untuk menyiasat kesan struktur cmEBG untuk mengurangkan masalah 'mutual coupling' pada 2.4 GHz. Oleh itu, pekali pemantulan kehadapan, S1,1 dan pekali penghantaran kehadapan, S2,1 antena 'microstrip array' dengan dan tanpa struktur cmEBG telah diperhatikan dan dianalisis.

ABSTRACT

This project was developed to apply the concept of Electromagnetic Band Gap (EBG) structure in antenna design. The application of EBG structure in the antenna design is important to reduce the mutual coupling which is the critical problem in designing the antenna especially the array antenna. This project consists of two experiments which are circular mushroom-like EBG (cmEBG) structure and microstrip array antenna with EBG structure. For cmEBG structure experiment, the method used was suspended transmission line method while for microstrip array antenna with EBG structure was inset feed microstrip transmission line method. The result of return loss, radiation pattern and gain was obtained by using CST Microwave Studio CAD Software. In cmEBG structure experiment, the EBG structure was designed to work efficiently at 2.4 GHz. A parametric study was performed on cmEBG structure to investigate its characteristics. The parameters involve was radius of cmEBG (rebg), radius via of cmEBG (vebg), substrate thickness (st) or via length (vl) and horizontal and vertical gap. The optimized design of cmEBG structure was applied into microstrip array antenna design to investigate the effect of cmEBG structure to reduce the mutual coupling problem at 2.4GHz. Thus, the forward reflection coefficient, S1,1 and forward transmission coefficient, S2,1 of microstrip array antenna with and without cmEBG structure was observed and analyzed.

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LIST OF ABBREVIATION

EGB	-	Electromagnetic Band Gap
PBG	-	Photonic Band Gap
EM	-	Electromagnetic
AMC	-	Artificial Magnetic Conductor
FR-4	-	Fire Retardant Type 4
3D	-	Three Dimension
FIT	-	Finite Integration Technique
PAMM	-	Patch Antenna and Microstrip Method
CMLM	-	Coplanar Microstrip line Method
MMIC	-	Monolithic Microwave Integrated Circuit
cmEBG	-	Circular Mushroom-like Electronic

CHAPTER 1

INTRODUCTION

1.1 Introduction

In this sophisticated era of communication, most of the physicist and researcher are keen to produce and design the antenna in order to increase the performance of the antenna. Generally, antenna can be defined as a device for transmitting or receiving radio waves [1].

The antenna has become a necessity and a vital component, without it the system will be malfunction. In this current telecommunication era, it has been widely used in telecommunication gadgets such as smart phones, tablets and wireless devices. Indeed, the effective antenna builds in the gadget or device must have a special requirements which is low-profile, well-function, small size and broad bandwidth. These characteristics of antenna have become a challenge for the antenna designers. Therefore, designing the antenna for telecommunication purpose is not as easy as erecting the metal rode at the roof top.

There are a lot of problems faced by designer including the increasing gain of antenna, suppressing surface wave in the antenna ground plan and reducing the size of

the antenna. Therefore, the designers have come out with the solution which is by applying the EBG structure into their designed antenna.

In recent years, the EBG structures have been widely used in the electromagnetic and antenna community [2]. According to [3], EBG structure can be defined as artificial periodic or non-periodic objects that prevent or assist the propagation of electromagnetic waves in specified band of frequency for all incident angels and all polarization states. The first EBG structure or previously named as Photonic Band Gap (PBG) was conceptualized and manufactured in 1991 by Eli Yablonovitch at Bell Communications Research in New Jersey by fabricating the crystal structure [4]. In addition, the designers has been used the PBG as a catalyst to create an EBG. As an example, a mushroom-like EBG structure was the proposed by Sievenpiper et al.

1.2 Problem Statement

The EBG structure is an interesting topic in antenna engineering which able to attract attention from the designer to come out with new design and new application. EBG can be use to block surface wave excitation, reduce mutual coupling, reduce cross polarization and enhance the performance of antennas in terms of gain, direction pattern, side lobe, back lobe and so on [5].

In microstrip antenna array, the EBG structures reduced mutual coupling effects between the adjacent patches, thus making them to radiate effectively [6]. However, there are a few problems in designing the EBG structure due to its physical appearance.

The size, durability and compactness of the EBG structure must take into consideration according to particular application without neglecting the performance of the antenna.

In this project, the circular mushroom-like EBG structure (cmEBG) and rectangular microstrip patch antenna will be designed and function at 2.4 GHz by using CST Mirowave Studio CAD Software. All the parameters involve will be observed and studied carefully in order to identify the characteristics of cmEBG structure toward rectangular microstrip patch antenna.

1.3 Project Objectives

The objectives of the project as follows:

i. To design, simulate and analyze cmEBG structure that will function at 2.4 GHz by using CST Microwave Studio CAD Software.

ii. To study the function of cmEBG structure in rectangular microstrip patch antenna.

iii. To solve mutual coupling that occur in rectangular microstrip patch antenna design.

iv. To miniaturize the size of the rectangular microstrip patch antenna arrays.

1.4 Project Scope

The project scopes in the project are as follows:

i. The cmEBG structure and rectangular microstrip patch antenna will be operated at 2.4 GHz.

ii. The simulation of cmEBG structure and rectangular microstrip patch antenna array will be conducted by using CST Microwave Studio CAD Software.

iii. The conventional rectangular microstrip patch antenna array will be designed with and without EBG structure.

1.5 Expected Result

In this project, the design of cmEBG structure should function optimally at 2.4 GHz. Then, the optimized cmEBG structure should be compatible with 2.4 GHz rectangular microstrip antenna to reduce the mutual coupling. Instead of reducing the mutual coupling, the size of cmEBG structure and rectangular microstrip patch antenna array should be design as small as possible.

1.6 Project Outlines

In this project, the overall report will be divided into five chapters:

Chapter 1 will present the brief introduction of the project, the problem statement, the objectives, the scope of study and the expected result.

Chapter 2 will be the literature review which elaborates more on the previous research regarding the EBG structure. Furthermore, the basic concept of EBG structure will also be discuss. The effect of the parameters involve in designing the EBG structure also will be elaborated. The fundamental parameters of antennas, types of feeding technique and types of transmission line also will be discussed.

Chapter 3 will present the methodology that is used in completing this project. The flows chart of the overall process and simulation process and will be provided and explained clearly. The formula involve in calculation of the parameters will also be included in this chapter. The method and techniques that will be use in this project also will be discussed.

Chapter 4 will present, analyze and discuss all the simulation results of cmEBG and rectangular microstrip patch antenna.

Chapter 5 will emphasize the overall findings of the projects. The recommendation for future research also will be stated.